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An Overview of mobile-Augmented Reality in Higher Education

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***Abstract*— Using the combination of virtual and reality methods can increase understanding in learning. Augmented Realityoffers a mixed reality which incorporates the digital environment in the real world. This paper presents an overview of AR, the types of mobile-Augmented Reality (mAR) applications being used in education, as well as other industries such as advertising, entertainment and tourism, and comparesthe different types of mAR interfaces in various mAR applications. In this paper, limited interface in higher education is highlighted.A framework for mARin learning is proposed that could potentially give an impact to students and educators. Using the appropriate mAR interfaces, the learning outcomes could be increased.**

***Index Terms*— higher education, interface, learning, mobile-augmented reality**

I. Introduction

Features of Augmented Reality (AR) are emerging in many mobile applicationsespecially for smartphones [1, 2]. However, far too little attention has been paid to the interfaces of AR in mobile applications.

This paper reviews the AR interfaces used in mobile applications across various fields such as advertisement, entertainment, tourism and education; both for indoor and outdoor settings. One of the main focuses of this paper is to understand the requirements of AR used in higher education. One possible hypothesis, yet to be proven, is that mobile AR (mAR) could help deliver the required learning information successfully to the students.

The paper starts by looking at the definition and history of AR. The paper then examines the interfaces and examples ofmARbeing used specifically for higher education. Finally, the paper describes and concludes with a proposed framework.

II. Definitions of Augmented Reality And Mobile Augmented Reality

The idea of AR is related to and extended from Virtual Reality (VR) or Virtual Environment (VE) [3]. AR lies between the real and virtual environment, and the state within these two environments is called a "mixed reality". A mixed reality integrates digital information in the real environment. According to Azuma [4], AR merges both types of objects either in 2D or 3D, leading to an interaction in real time which reflects the term mixed reality as depicted inMilgram'sVirtuality Continuum (VC) (Figure 1).In Figure 1, as the point moves toward the right leading to the Virtual Environment (VE), users will experience anenvironment surrounded by objects that exist in a virtual environment. In the VE, real objects may be added and mixed with the virtual ones. In contrast, the point on the left hand side of Milgram's VC as it moves toward the Real Environment, a range of digital objects such as videos, audios, images or haptic/ touch can be embedded and overlaid/

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augmented ontopof a Real Environment.

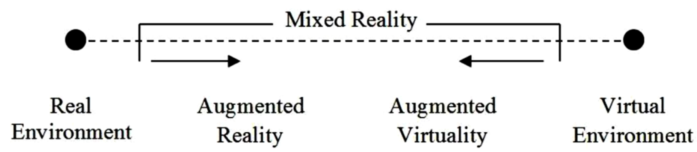

Figure 1. Milgram'sVirtualityContinuum

II. History of AR

AR is made of a collection of technologies and these technologies must be combined to make AR work. Some of the required technologies include global positioning and tracking, location-based computing and services, wearable computing and wireless communication [3].Mobile Augmented Reality (mAR) takes AR and makes it portable or mobile hence away from the traditional VR/VE settings of being a specifically purposed environment[3]. Emerging and affordable mobile technologies such as the ones found in smartphones have made it possible for mAR applications to be of practical uses.

III. History of Augmented Reality

In this section, a brief overview of some of the important inventions that contributed to the evolution of AR is presented.

A. 1962

In 1950, it started with the creation of the Sensorama by a cinematographer named Morton Heilig. His intention was to immerse viewers with on-screen activities by taking all of the senses of the whole story into their own real world experience. In 1962, he built a motorcycle simulator called the Sensorama and it wsconsidered as a multi-sensory technology that provided visual, sound, vibration and odor sensory experience.

B. 1968

Ivan Sutherland invented the first Virtual Reality (VR) device called "The Sword of Damocles Head Mounted Display (HMD)". Two years later, he went on to produce the first AR interface design system using an optical see-through HMD.

C. 1985

VIDEOPLACE was created in 1985. VIDEOPLACE was the first system which allows the user to interact with virtual objects in a real time application. During this time, the system was recognized as Artificial Reality.

D. 1992

The term of "Augmented Reality" was coined by Tom Caudell and David Mizell in a project called Boeing's Computer Services' Adaptive Neural Systems Research and Development. The softwarewhich can overlay positions of certain cables to be placed in a building assisted Boeing in their manufacturing and engineering processes.

E. 1994

Paul Milgram and Fumio Kishino came up with the Milgram'sVirtuality Continuum(Figure 1). Augmented Reality (AR) is a variation of Virtual Environment (VE) or Virtual Reality (VR). Ideally, the VE technology immerses the users completely into the virtual world without noticing or seeing what actually happens in the real world. In contrast, AR deals with both environments. The user is able to see and experience the virtual and real world environment at the same time [4].

F. 2000

Desktop AR which uses a desktop computer has been made available to the consumer market and it has shifted the consumer experience with respect to AR. The first outdoor mAR game was built at the University of South Australia. The game is calledARQuake with the aim of eliminating reliance on the joystick gaming device. The whole idea of ARQuake is to mobilize the application, to enable the user to step in and outindoors and outdoors, and to allow users be fully immersed in the gaming environment and sensory perceptions. The walls in the Quake world are represented by the exterior buildings in the Mawson Lake campus at the University of South Australia in Australia.

G. 2008

Wikitude introduced the first mAR application forsmartphones by developing an application called the Wikitude Drive. This augmented navigation application directs drivers to a particular location just by using a mobile device.

IV. INTRODUCTION TO MOBILE-AUGMENTED REALITY

As a display technology, mAR could replace the HMD, binoculars, helmets etc. mAR is a rapidly emerging research area within AR and some of the research include the use of GPS tracking, user studies, visualization and collaborative applications.
Study by[5] state that mobile devices such as smart phones and tablets are the most widely used technology. They can be found in advertising, construction, education, entertainment, journalism, maintenance, personal location based-information, navigational aids, tourism, etc.
Prior to creating and using an mAR application, there are a few specific requirements in terms of devices and interactions.

A. Devices

Displays

AR is all about the integrations of a real world with a virtual environment. In order to use an AR application, a display device is required which can enhance user's perception and accommodate interactions with the application[6]. There are a few types of AR display devices such as see-through head-mounted display (HMD), projective and handheld [6].

Head Mounted Display

HMD is also known as the near-to-eye display. It is a device that a user wears on one's head. Modern HMDs as such offerquite a good visual fidelity hence is a perfect tool for AR. The HMDcan convey the view quite close to the user's eyes and it allows a user to experience a perceived large screen effect.Unlike traditional HMD, a see-through HMD is required for AR so that virtual objects can be overlaid on top of the real world, and simultaneously allowing the user to still walk through the real world.

Projective

In a projective type display, visual information is directly projected onto a physical object to be augmented. A camera is required for viewing the augmented objects. Projection-based AR with video augmentation uses video projectors to show the image of an external video camera augmented with computer graphics on the screen. The AR physical object can randomly shape real environment and it uses the real world as the base to project the augmented object on real surfaces and settings.

Handhelds

Some AR applications can be viewed on handheld devices such as smartphones and tablets. They use the back camera to capture the real world surroundings and the front panel display to view the augmentations such as the information that has been highlighted by specific AR markers [7].

Tracking

According to [6], general tracking for AR includes mechanical magnetic sensing, GPS, ultrasonic, inertia, and optics[6]. Tracking is a method of registering what is being captured by the camera and merges the virtual image generated by computer. The most common tracking methods used is position and orientation. Trackingthe position initiates the graphic system to render views from the user's position. There are several other methods for mAR tracking which include the use of digital camera and/or other optical sensor, GPS, accelerometer, solid state compass, wireless sensor etc.The quality/level of accuracy depends on each technology.

Computer

An AR system requires a capable CPU and a sufficient amount of RAM to process all of the real time image captured from the camera[6]. Nevertheless, in recent years, there have been quite a substantial advancement in research and development in mobile computing systems. Many modern computer systems especially smartphones and tablets are now much more compact and lighter, more affordable and have a handheld form factor [1].

B. Interaction with mAR

Basic Interaction : selection and manipulation

One common interaction method is via haptics interface, such as a touch screen on a moble device[8]. Being relatively smaller with interactive surface area, in comparison to traditional mouse-pointers on desktop monitor, this technique has limitations. To overcome this limitation, it is imperative that additional buttons and/or screen icons be installed to allow for a more natural feel for finger interaction with AR objects.
In other words, mobile devices acts as a magnifying glass in order to see what is occluded behind a mere real object. The user may use finger touches to interact with augmented object, for instance to zoom in/out, to rotate, to click etc.

V. MAR INTERFACES

An interface should have intuitive interactive characteristics between the user and the mAR system. There are four main types of mAR interfaces. They include tangible interface, collaborative interface, hybrid interface and multimodal interface. In this paper, multimodal and hybrid interfaces will be highlighted to deliver factual learning activities in higher education. With these interfaces, students are expected to be able to interact with the topic where they can enlarge a specific part of the subject matter and explore it in more detail. Multimodal and hybrid interface are emerging as the preferred interface for future mAR application due to the perfect interaction in terms of its "robustness, efficiency and expressiveness" [1].
Reference [8]describes a common mAR interfaces using touch screen based on any selected information. They propose a basic concept of the application with small feature sizes, specifically if the buttons and icons were to be clicked or touched by large fingers. This application was presented in 2-dimension and has been widely used in most applications that have the same function as a desktop computer in terms of mouse clicking. However, in the same study they emphasized this small size issue is natural, depending on the gesture of interaction, based on user's finger tracking in front of a phone's camera. While this approach can be applied for gaming and entertainment, [9] said it has to be "in combination with standardized graphical interface objects (widgets or controls) which enables users to control arbitrary applications".
Therefore, an AR interface is a medium for information projection combined with real world environment mapped with augmented surrounding in a single view. AR that is being deployed onto mobile devices, for example a smart phone, uses the smartphone's camera to analyze the physical environments in real time and overlay the augmented interface onto it.

A. Types of mAR Interfaces

Tangible Interface

The *tangible AR* interface supports direct interaction by utilizing real equipments, physical objects and tools [1] such as mobile phone, car key, spectacles and etc. TaPuMa is one of the examples of the tabletop screen map which uses personal belongings to interact and access any relevant information or direction from the map.

Collaborative Interface

Collaborative AR interface refers to multiple displays that support co-located and remote activities. Co-location enhances the display and improves the physical collaboration using 3D interfaces. On the other hand, remote sharing allows multiple AR devices to be integrated with multiple locations, hence enhancing teleconferences [1].

Hybrid Interface

A hybrid *AR* interface allows users to focus on a specific physical object. Once the system recognises the object, relevant information will be displayed on screen.

Multimodal Interface

Multimodal AR interface merges real objects and the system in the form of languages and behaviours namely speech, touch, natural hand gestures, or gaze [1]. In addition, multimedia elements are also present in the application to enhance user interaction. For example, to explain the respiratory system, students will be able to study using the interactive mAR application rather than examining a physical dummy object or by just reading a textbook. With a multimodal AR interface, it offers more enjoyment for students. In other words, the user may interact with the application by clicking the buttons just like a courseware and the augmented object will be displayed [1].

VI. Reviews of mAR in Education

AR is proven as a tool to strengthen motivation for learning According to[10], AR should be further explored to support a mobile learning environment in higher education. Even though there were issues related to AR in terms of equipment, integrating it with traditional learning methods, the cost of the development, maintenance and conflicts with emerging technologies; these shortages have been resolved[10]. Hence, mAR now has the potential to enhance learning and capture the learners' attention more and increase motivation.

In this paper we propose anmAR framework for higher education that can enhance learners' motivation and attention especially when dealing with complex objects, for example in learning human anatomy. According to reference [11] biology students have problems in maintaining the informationthey learned. This mAR proposes a framework to support this study [11], in order to retain information that could last longerafter learning biology subject.

A. Conventional Learning of the Human Anatomy

The conventional way of learning human anatomy is grounded on the dissection of a human body. This type of learning style has a lot of advantages as it provides a detailed study of the structure of bones, skeletal elements either in articulated or non-articulated form.

Despite many of its advantages, there are still challenges in learning the human body anatomy. Some of challenges are storage of the cadavers, moral issues, the quality and limited quantity of cadavers, limited lab opening hours, and low retention of information [11].This paper focuses on these gaps in learning human body anatomy by proposing a learning style that can mobilise the learning environment using mAR.

B. Computer Supported Learning of the Human Anatomy

Learning the human anatomy using computer is quite common nowadays. Using CD-ROM or web-based coursewares, theyincludemultimedia (audios, videos, images and texts) support and valuable additional links. Using multimedia especially visual images is part of a spatial learning style and it has attracted researchers to implement it more as part of theirteching methods.

Multimedia elements have given a great impact in supporting a more interactive learning environment. Due to all issues that have been raised, education regarding human anatomyseizes the opportunity to use technology intervention to enhance the learning style. By using visual anatomic, complex structures can be more understood [12]. This visual technique is mostly used in VR and AR technology.

Below are some examplesof how mAR technology is being utilized in higher education.

A. Creating Augmented Reality in Education (CARE)

In the Creating Augmented Reality in Education (CARE) project, presented two cases of mAR; the first case uses mAR in clinical skills for lab treatment where students were exposedto a clinical lab environment to learn the skills needed in the operating theatre, in accident and emergency circumstances. mAR helps overlay those environments into a normal practice, hence increasing knowledge and enriching students' clinical skills, while simultaneously decreasing their nervousness. mAR also supports the self-centred learning concept and does not require the extra hours to run a lab or require academic staff/lab technician to monitor the students from CETL (Centre for Excellence in Teaching and Learning) in London, United Kingdom.

As part of the locality project for the nursing students' orientation, the second case is related to tracking the location of points of interest around the East London route. Students were required to use the Layar browser on their mobile devices to find certain places and complete the tasks given once they have reached them. By using mAR, students were able to access information associated with the surrounding areas. Students work in groups in order to have a more collaborative and self-directed learning.Augmented Collaborative Campus (ACCampus)

The next example is the Augmented Collaborative Campus (ACCampus). The ACCampus refers to the physical environments equipped with the Quick Response (QR) codes. In order to obtain information, students were able to interact with areas which have QR codes. The areas include wall class boards, windows and doors. These areas allow students to interact freely with the QR codes provided by the university to acquire fascinating and collaborative information and activities. Furthermore, by using mobile devices, the augmented information could be projected onto a 2D or 3D interface. The ACCampus uses QR codes instead of GPS due to the fact that the AR walls are indoors hence no GPS signal is available. The mAR environment can be viewed by aligning the mobile phone camera with the QR code.

B. Cultural Science Field Trip

The Cultural Science Field Trip is another study conducted by [13]. In this study, mAR is utilized in a cultural science field trip in different types of game design, delivery channel and pedagogical approach of case studies. This application is designed for navigation and exploration. It is somewhat of a gaming concept for the students to be involved with.

In Case study 1: *Florence*; has the concept of a scavenger game and situated learning. The students must explore street views using GPS and utilize the full function of the application, and after obtaining the vision of a street view, they were required to complete the given tasks.

In Case study 2: *Hostage*; requires decision making skills in completing the assignments by navigating using the mAR application. These two location–based case study examples applied team-based effort amongst the students to collaborate with each other, to aim for high scores; hence increasing the learning performance. Based on this study by[13], they discovered that the quality of essays from the mAR group of students is higher than that of the non-AR group. In addition, mAR has the potential to enhance the learning outcomes and educational experience if it is integrated effectively into the learning environment

VII. Mobile Augmented Reality in other Industries

A. Advertising

Another application of mAR can be found in advertising and branding where this technology enhances the needs of marketing strategy[14].According to a survey done by the web ARSurvey of Web-based ARApplications in 2011 [14], it has been proven that mAR is a powerful medium for product advertising in marketing specification. UtilisingmARcan attract and efficiently convey the product information as well as in Point of Sales (POS). With respect to the cost, mar is cheaper compared to television advertisement. Due to the mobility feature of mAR, it is a viable business opportunity since users can view information anytime, anywhere and further interact with the advertisement.

PROTON is a Malaysian car manufacturer that offers mAR for potential buyers to be familiar with their products. Interactive buttons will appear where the buyer can click on to seek more information about each part of a car’s chassis.

Another company that is uses mAR for marketing is Heinz. The Heinz brands employ AR technology as a persuasion strategy for their product. When a user wants to buy ketchup and during the buying process, he/she may discover various recipes in the form of multimedia interactive application. The user can interact with the application that can provide videos on how to prepare dishes using the respective product.

B. Entertainment

AR allows us to overlay digital information upon the real world. In a creative atmosphere, AR enriches the information in presenting parts of a multimedia production specifically for storyboarding.

A study has conducted three demonstrations. In the first demonstration, *The Lion King* was attached to markers. Contents such as static images and texts, as well as movie clips which repetitively streamed were added to the storyboard. It offered a demonstration of every scene during the discussion process. The beauty of this implementation was the ability to make almost immediate amendments during discussion, with the visual images that granted high understanding about what will be executed in scenes for the final production

The second demonstration utilized digital comic books where their content can be updated from servers. Readers were able to recall past comics from previous weeks and present all in one story timeline; hence providing a continuity to the story. For example, in the past two days, comic markers were kept and placed on the refrigerator door. Using mAR, a reader was able to view new comic feeds or information by refreshing the application every day.

The third demonstration was a puzzle game. Using different height and width of augmented images from different markers, specific contents were presented. When all pieces of the markers were properly aligned, one big augmented image was created hence completing the puzzle.

C. Tourism

mAR can also be found in tourism. In tourism, visual information is provided by the mAR application. For example, by simply pointing a smart phone’s camera’s viewfinder toward a location of interest, a specific location chosen will be shown on the screen. Some of the information can includes restaurants, places of interests, attractions, historical facts, Wi-Fi hot spots, car parks, ATMs, transportation routes, local news, weather, and many more. The display of visual information is made possible through the concept of Point of Information (POI) where relevant information is being displayed and updated at any time and place, and in real time. There are quite a number of internet browsers that supports AR's; e.g.Wikitude, Blippar, Junaio, Layar and etc. Some AR supported applications are meant for specific purposes such as to obtain information in the midst of wandering/sightseeing at certain places; e.g. the Wikitude browser offers several categories such as travel and tourism, accommodation, events, foods etc. Another example is the Layar browser where it can direct a tourist to where an art gallery is located and once reached, more information is presented such as a description of the architecture of the art gallery and etc.

VIII. COMPARING THE DIFFERENT MAR INTERFACES IN VARIOUS INDUSTRIES

There are a number of important interfaces between education field and other applications. A summary is as shown in Table 1. Table 1 depicts the current types of mAR interfaces in numerous applications as discussed earlier. This may suggests that the current use of AR in mobile devices has been generally lacking in few interfaces especially in education.

It shows that only two interfaces are being applied in education; the tangible and the collaborative interface. For advertisement, it implements all types of interface based on the higher success rate of selling product from the advertisement of the product efficiently. A study has proven that an advertisement employing the multimodal technique with interactive courseware function, delivers quality products and services and without forcing customers to view the information. The customers are driven by their curiosity to interact with the mAR application. In addition, customers feel a "heightened degree of intrinsic motivation, intense concentration and enjoyment while engaging with mAR and increased learning and participation" [15].

By implementing the same concept of a hybrid or multimodal interface with the learning environment, it may boost the learning outcome of students as well as their motivation, and it will also be beneficial to educators (Figure 2).

TABLE 1. COMPARING THE DIFFERENT MAR INTERFACES IN VARIOUS INDUSTRIES

Current mAR	Types of mAR interface							
Application	Tangible		Collaborative		Hybrid		Multimodal	
Dimension	2D	3D	2D	3D	2D	3D	2D	3D
Education	√	√	√	√	x	x	x	x
Advertisement **Interactive product evaluation*	√	√	√	√	√	√	*√	*√
Entertainment	√	√	x	x	x	x	x	x
Tourism	√	√	x	x	√	x	x	x

IX. PROPOSED MAR FRAMEWORK FOR EDUCATION

This paper proposes a framework which consists of combination of interfaces such as multimodal and hybrid as stated earlier. This conceptual modelbenefits and supports the concept of student-centred learning with mobile-Augmented Reality (mAR) as an assistive learning tool in higher education environment (Figure 2). It can be argued that mAR can provide benefits to learning activities by allowing faster access to information and providing information on demand, increasing the student's motivation to engage in learning activities, making the learning process easier and more efficient, and helping the students in understanding the concepts better [16]. However, the implementation of mAR technology within the classroom learning is still weak[17]. According to[18]mAR has the potential to enhance the learning outcomes and educational experience if it is integrated effectively into the learning environment. Based on the comparative review done (Table 1) the multimodal interface has increased the sales in product advertisement. By proposing the same concept of hybrid and multimodal interface within the learning environment, it hopefully boosts the learning outcome of students as well as their motivation, and it will also be beneficial to educators (Figure 2).

The learning outcome is one of the vital substances to focus. Reference[2]has proposed a theoretical model which categorizes the learning outcomes into three components; the cognitive learning outcomes which include knowledge, comprehension, application, analysis, synthesis and evaluation; the affective learning outcomes which include students' perceptions of satisfaction, motivations, respect and appreciation for the learning experiences [2]; and the psychomotor learning outcomes which refer to efficiency, accuracy and response magnitude [2].

Reference [19] draws the attention in learning outcome by using a Virtual Learning Environment (VLE) method. The term VLE is defined as "computer-based environments that relatively open systems, allowing interactions and encounters with other participants." [19]. The VLE as described above is where students are individually involved in a self-centred based learning environment and classroom environment together with diverse technologies as tools to support learning. Throughout this VLE framework, the learning outcome is measured through the effectiveness of these three dimensions, which include; performance, satisfaction and self-efficacy.

Human dimension comprises of students and teachers. It breaks down into maturity, motivation, technology comfort, technology attitudes, previous experience, computer anxiety and epistemic beliefs. While for teachers, the breakdown are technology controls, technology attitudes, teaching style, self-efficacy and availability.

In most cases in a virtual development, design is the salient issue that must be put into consideration because it gives great impact to the users. In the framework suggested by[19], the design dimension consists of the learning model (objectivist, constructivist); technology (quality, reliability; availability); learner control (pace, sequence, content); content (factual knowledge, procedural knowledge, conceptual knowledge); and interaction (timing, frequency, quantity).

In this framework, the effectiveness is the dependent variable consisting of three antecedents, for instance performance (achievement, recall, time on task), self-efficacy and satisfaction. Effectiveness is measured through performance. It is more likely to achieve the goal; recalling what have learnt from the subject and completing the given tasks on time. Self-efficacy symbolizes people's opinion on how a learner is capable and competent in organizing and executing the required actions [19]. Whilst satisfaction represents the evaluation of the effectiveness of learning environment in an academic setting. In the field of teaching and learning environment, it is important to assess students' satisfaction because it relates to students' engagement in the learning activities, when and where they favour, learn at their own pace, and to mark the significant material to engender a positive interest.

By adopting the VLE's context in the mAR proposedconceptual model, learning outcome can be measured through the quasi-experimental method in the next research. Referring to Figure 2,is the prediction environment ofsatisfaction and motivation which will be beneficial to the education environment. Satisfaction consists of quality and style of delivery, content and perceptions. By applying a multimodal and hybrid interface, it is likely to produce a high understanding for the students. Thus, it will increase the students' motivation to study a subject in greater earnest. In this paper, the motivations' characteristics are context, internal representation and process of learning. These characteristics will be as antecedents in the proposed framework to obtain the effect of students' motivation and to improve student learning outcome. An argument from [5] stated that salient attention needs to be addressed on the students' learning side.

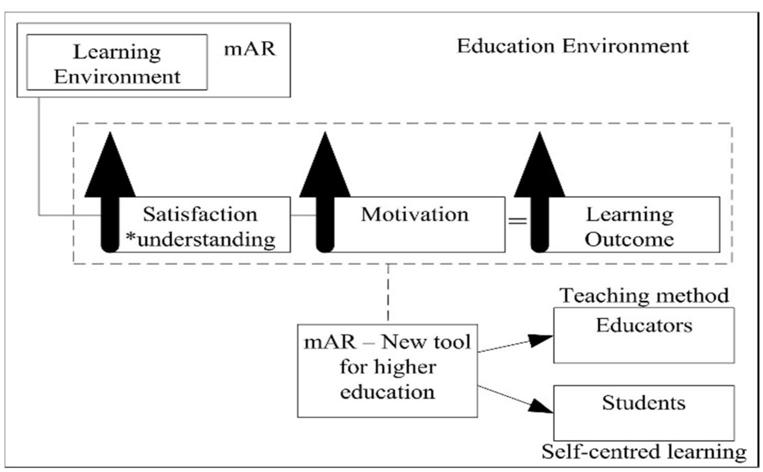

Figure 2. Proposed mAR framework for education

Therefore, we propose mobile-Augmented Reality (mAR) as a learning tool in higher education, focusing on the topic of Biology. In a study by [11], students who learned Biology were unable to generate a long lasting understanding of the subject. By using mAR, experimental groups will be recruited to experiencethe mAR to encounter the issue. The mobility of mAR using a multimodal interface will give students the freedom in clicking and viewing the application at their own pace. mAR is a technology that can mobilise learning environment regardless of location and timing, and it has the flexibility based on the students' need. This self-centered learning technique cansupport and enhance students' learning outcomes.

To improve the connections between students and mAR application as well as to enhance the learning outcomes, multimedia elements will be presented. The multimedia elements play an important role to make people perform well in receiving and understanding messages. This effect will provide better visualization, enjoyment of exploring a topic and provide a high impact of memorization of an object; hence boosting students' motivation in learning.

mAR is also beneficial and can assist educators in teaching topics that required more understanding about complex objects. The result obtained from[5] has been strongly challenged in recent years by [20], who suggested that educators need to take portions in implementing technology for a better quality in learning,in essence, to produce effective teaching method and excellent students in the future.

X. Methodology

The quasi-experimental research using quantitative analysis method will be used and is considered as the most appropriate. The function of a research design is to make certain that the evidence obtained enables the research to respond to the initial questions as unambiguously as possible. There are good reasons for selecting the quasi-experimental approach as it relates to human behaviour and perspectives.

The pre-test and post-test control group design will be used in this research. The pre-test and post-test control group design is a mixed-design. A mixed-design is a factorial design widely used in social science, especially in education and psychology. Furthermore, it can reduce the threats to internal validity through the manipulation of one or more independent variables and the measurement of dependent variables that can influence the researcher's ability to pinpoint any differences between groups.

The population for this research will be at the tertiary level namely universities. This decision is made based on the aforementioned problem statements whereby many of the previous studiesstate that mAR technology has been ignored in the learning environment in general and particularly at the university level. Based on these studies, the role of mAR as part of the teaching and learning process has not been sufficiently investigated.

In order to suggest and propose an appropriate mAR framework in higher education learning environment, Structural Equation Modeling (SEM) will be used. SEM is to observe the inter-relationships among variables in a model. Once the model's parameters in the proposed framework have been analyzed, a cross-sectional statistical modeling technique for the framework will be confirmed in terms of modeling fitness. This model fitness will be used in AMOS software, it has five refinement model validation steps; 1) model specification, 2) model identification, 3) model estimation, 4) model testing and 5) model modification.

Thesesteps are designed to obtain a fit for the mAR framework according to all the dimensions proposed earlier for the mAR environment.The proposed framework will be thoroughly tested in terms of framework modelling for more learning environment in higher education.

XI. Conclusions

This paper examined the types of mAR interfaces found in some important applications. As mAR is gaining attention in higher education, this paper presented a proposedframework that comprises important mAR interfaces to enhance the use of mAR for learning. According to [10], AR should be further explored in the context of being a mobile learning environment in higher education. We propose anmAR framework for education forinvestigating perceived learning, satisfaction and self-efficacy among students (Figure 2).The proposed framework also shows that understanding and high motivation inthe learning process will affect the learning outcome. It is hoped that the implementation of mAR learning could bring an increase to the motivation of student-centred learning in higher education.

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